NAVFAC
Naval Facilities Engineering Command
NAVFAC HAWAII

AOC Parties Technical Working Group Meeting No. 21

Red Hill Bulk Fuel Storage Facility
July 30, 2019

Agenda

- Introductions
- Meeting Objectives – Requirements of the AOC Sections 6 & 7
- Big Picture Overview and Discussion
- **Break**
- Key CSM Changes in the GW Flow Model Setup and Features
- Additional GW Flow Model Updates
- **Working Lunch**
- Regulatory Agency GW Flow Model Discussion
- **Break**
- Regulatory Agency GW Flow Model Discussion (continued)
- Summary of Key Follow-ups for Day 2 meeting
- Meeting Adjournment

Meeting Objectives – Requirements of the AOC Sections 6 & 7

- Focus on the key issues that drive the decision-making process
- Consider the current groundwater flow modeling timeline
  - Submit to the Regulatory Agencies by October 5, 2019
  - CF&T Model Report to be submitted 6 months following Regulatory Agencies' approval of the Groundwater Flow Model Report
- Strive to gain alignment on CSM, IRR, and Groundwater Flow Model Reports
- Overarching considerations for the technical issues
  - Help leadership make informed decisions
  - Complete within agreed-upon timeframes

Meeting Format

- Stay collegial
- Allow SMEs to have open technical discussions
- Participation from all parties
- Technical slides are designed to facilitate discussion among SMEs – not a formal presentation

Big Picture Overview and Discussion

Big Picture Overview and Discussion

- Key changes to GW CSM since July 2018 submittal
- How Navy plans to update CSM with results from the LNAPL modeling effort

Key Changes to CSM since July 2018 Submittal

Document Section	Revisions
Module A: Physical Setting	- Revised Volcanic Rocks Discussion - Updated Groundwater Monitoring Network (new wells) - Updated and addressed uncertainties
Module B: Facility Construction & Operations	- Updated Types of Fuels Stored at Facility - Added description of Tank S-355 slop tanks
Module C: LNAPL Release Source Zone	- Modified section title from "…Source-Zone Migration Model" to "LNAPL Release Source Zone" - Added information on: slop tank, recent construction and upgrades (oil-tight doors), and current conditions of facility infrastructure (EPA 2017 system evaluation report) - Added information on Former OWDF - Expanded discussion of saltwater corrosion in tanks - Updated and addressed uncertainties
Module D: Vadose Zone	- Added or revised discussions on strike/dip and gaussian distribution, preferential pathways, tuff and caprock deposits, saprolite, and permeability - Added information on Geologic Framework Model, Petrographic Analyses, and Infiltration Study - Updated and addressed uncertainties

Key Changes to CSM since July 2018 Submittal (continued)

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Document Section	Revisions
Module E: Saturated Zone	- Updated water level elevation data with more recent data - Added TFN/Pair-Wise Analysis - Incorporated barometric corrections to synoptic data, Cooper-Jacob approximations to the Theis method, and Aqtesolv estimates of aquifer properties - Updated and addressed uncertainties
Module F: Fate and Transport of Dissolved COPCs in Groundwater	- Updated the summary of dissolved-phase COPCs detected in groundwater with current monitoring results - Updated information on natural attenuation - Updated Groundwater Flow and Contaminant Fate and Transport Modeling section - Added groundwater chemistry lines of evidence - Updated and addressed uncertainties
Module G: Exposure Module	- Clarified definition of exposure model - Revised discussion on ecological receptors and on potential and incomplete/insignificant pathways - Updated and addressed uncertainties

Key Changes to CSM since July 2018 Submittal (continued)

Document Section	Revisions
Appendix A: Cumulative Historical Groundwater Monitoring Results and COPC Concentration Graphs	- Updated with cumulative results as of First Quarter 2019 LTM event - Added EPA split sampling results
Appendix B.1: Thermal NSZD Analysis	- Revised discussion on background well, protocols and calculation method terminology and descriptions, and aerobic conditions observed - Revised results for Calculation Method 2 (Model-Correction) (formerly Thermal Profiles Method) and Calculation Method 3 (Groundwater Temperatures)
Appendix B.2: Carbon Trap NSZD Analysis	- Added discussion on reason for difference in NSZD Rates between upper and lower tunnels
Appendix B.3: Soil Vapor Analysis	- Added monthly PID monitoring results through January 2019
Appendix B.4: MNA Primary Lines of Evidence and Rate Calculations	- Clarified reporting limit discussion - Revised discussion of methods, rate coefficients, and discussion of results, for plume duration and plume attenuation - Revised estimated plume bulk attenuation rates

Key Changes to CSM since July 2018 Submittal (continued)

Document Section	Revisions
Appendix B.5: MNA Secondary Lines of Evidence	- Clarified qualification of analytical data and reporting limits - Updated plots with monitoring data through February 2019 - Added DO and ORP to plots
Appendix B.6: Microcosm Study and Microbial Parameter Analysis	- Microcosm study: updated incubation periods, revised constituent-specific rate coefficients, and expanded discussion of findings - Microbial parameter analysis: updated discussion of findings and added laboratory reports
Appendix B.7: Forensics and Data Evaluation - Groundwater	- Revised text to limit discussion to jet fuel chemistry and evaluation of dissolved material measured as TPH-d - Revised discussion of dissolved material measured as TPH-d in groundwater

Key Changes to CSM since July 2018 Submittal (continued)

New Appendixes	Description
Appendix B.8 – Comprehensive Evaluation of Groundwater Chemistry	- Developed multiple LOEs to assess potential impact to groundwater after the 2014 Tank 5 release - Developed additional LOEs to evaluate whether or not there were potential impacts to outlying wells from prior releases
Appendix C: Strike and Dip Data	- Strike/dip azimuth field measurements
Appendix D: Evaluation of Potential Pahoehoe Lava Flow Paths through Tank Farm Area	- Random walk modeling of potential historical lava flow paths to evaluate the potential for lava tubes acting as preferential pathways
Appendix E: Geologic Framework Model	- Description of current stratigraphic model: geophysical investigation, new cross-sections, tuff complex, marine sediments, and alternative saprolite evaluation/interpretation for South Hālawa Valley
Appendix F: Petrographic Analytical Report	- Petrographic laboratory analytical report
Appendix G: Infiltration Study	- Geotechnical results of infiltration testing

Key Changes to CSM since July 2018 Submittal (continued)

New Appendixes	Description
Appendix H: Transfer Function-Noise Analysis of 2017 – 2018 Synoptic Monitoring	- Analysis of 2017–2018 synoptic monitoring data to extract information for numerical groundwater model calibration and estimate equivalent regional-scale aquifer hydraulic properties
Appendix I: Multiple Impact Factors	- Comparison of DO concentrations between Red Hill and other sites, analysis of potential drilling impacts on TPH-d detections in groundwater, and a multiple impact factor analysis to provide additional LOEs
Appendix J: Regulatory Comments and Navy Responses	- Regulatory Agency comments on CSM Revision 00 (July 27, 2018) and Navy responses

How Navy Plans to Update CSM with Results from the LNAPL Modeling Effort

- LNAPL modeling not part of AOC work plan
- **LNAPL modeling not currently funded**
- LNAPL modeling not tied to **AOC deliverables**
- **Based on a request from the regulatory agencies, the Navy developed a potential LNAPL modeling approach (Simplified 3D LNAPL model) for consideration**
- **The Navy has evaluated key parameters for use in the Simplified 3D LNAPL model and has presented those to the regulators for consideration and comment**
- **Alignment between AOC parties on how LNAPL modeling could be performed has not been reached**
- Since no agreement has been reached on how to perform LNAPL modeling, no information has been developed to integrate into the CSM (or the IRR)

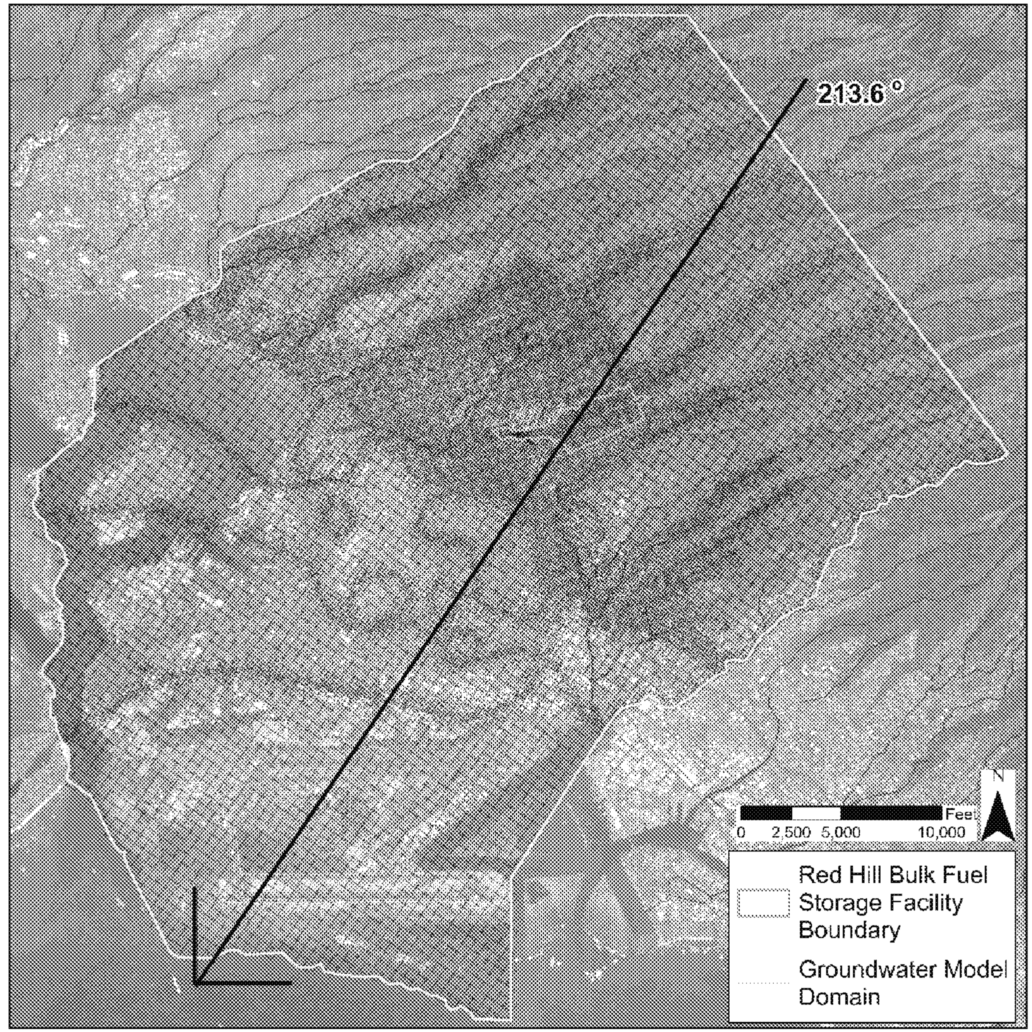
Key CSM Changes in the GW Flow Model Setup and Features

Key CSM Changes in GW Flow Model Setup and Features

- Updates to geology – tuff, tuff cones, marine sediments, alluvium, saprolite
  - –Previously presented at multiple meetings
- Updates to model grid
- Update to Red Hill Shaft orientation
- How have these changes affected the model behavior?
- USGS recharge variants
- 2017/2018 Synoptic Study data
- Model uncertainties & Calibration data needs
- Transfer Function-Noise (TFN) analysis

Key CSM Changes in GW Flow Model

- **Updates to model grid:**
  - Following a site visit between the Navy and DOH on November 28, 2018, the AOC Parties agreed upon 213.6 degrees as the dip azimuth and 2.9 degrees for the dip magnitude.
  - A detailed grid level summary will be provided at the GWMWG Meeting.



Key CSM Changes in GW Flow Model

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- **Update to Red Hill Shaft orientation:**
  - Navy noticed that the shape file for the water development tunnel used to date did not match the orientation presented in the ca. 1942 Navy as-built drawings and in the Stearns 1943 section and plan view of the tunnel.
  - Navy provided shape files of the tunnel on April 26, 2019 that matched the 1942 Navy as-builts and Stearns 1943.
  - A decision was made based on the preponderance of evidence to use the orientation that is consistent with the 1942 Navy as-builts, Stearns 1943, and recently provided Navy shapefiles. In response, the orientation of the water development tunnel was updated in the groundwater flow model.

Update to Red Hill Shaft Orientation

Key CSM Changes in GW Flow Model

- **How have these changes affected the model behavior?**
  - **Tuffs**
    - Impede lateral flow
    - Need to watch for unrealistic water-level buildup in tuff zones
  - **Saprolite – the two interpretations (A and B) will be tested against each other during calibration**
    - Interpretation A is deeper saprolite depth (-55 ft msl), and interpretation B is shallower saprolite depth (-5 ft msl)
    - Better match to targets?
    - Less deviation from preferred parameter values?
    - Less heterogeneity required?
    - Early runs indicate differences, but which is preferable can't be determined yet
    - Use Interpretation B if they are of similar quality
  - **Red Hill Shaft alignment impact to calibrated aquifer parameters as a function of distance from the water development tunnel**

Key CSM Changes in GW Flow Model

Key Point: Regionally, recharge generally scales up or down depending on weather

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Key CSM Changes in GW Flow Model

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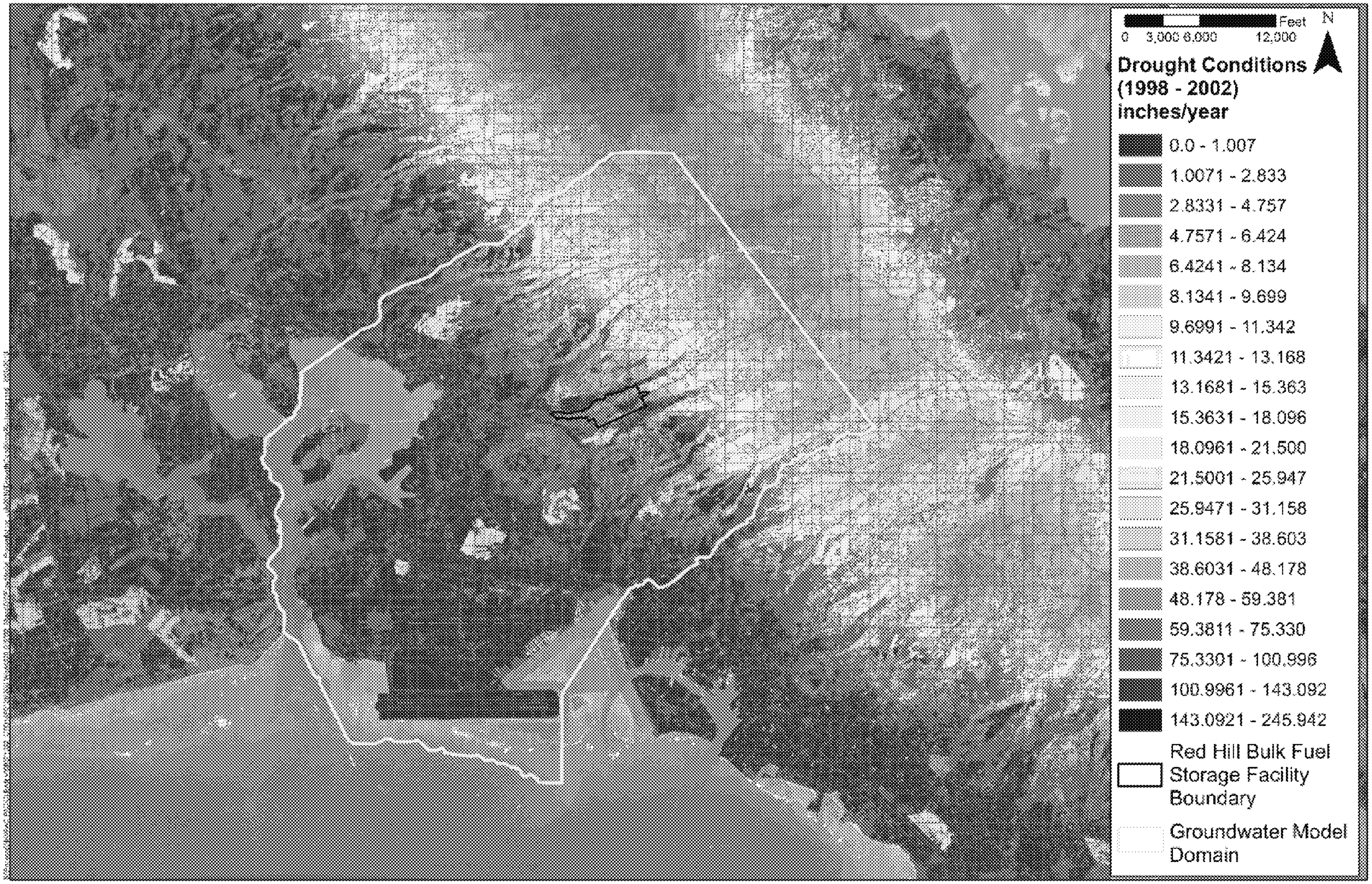

Key Point: Regionally, recharge generally scales up or down depending on weather

Key CSM Changes in GW Flow Model

- **2017/2018 Synoptic Study Data:**
  - Data collected as part of recent synoptic water level studies assisted with aquifer hydraulic property estimates and evaluation of groundwater flow conditions in the site area.
  - Kansas Geologic Survey Barometric Response Function software (Bohling, Jun, and Butler 2001) was used to address barometric fluctuations and ocean tide influences.

Key CSM Changes in GW Flow Model

Model Uncertainties and Calibration Data Needs

- Model uncertainties addressed via multi-model approach and via conservative assumptions
- Calibration data acquired from synoptic study
- Unit response functions generated through TFN analysis

Key CSM Changes in GW Flow Model

- **Transfer Function-Noise (TFN) analysis:**
  - A TFN was completed using the 2017–2018 synoptic water level data. The TFN analysis simulates the water level response to each hydraulic stress component (e.g., barometric pressure, pumping from shafts, tidal and other influences) through evaluation (convolution integration) of the hydraulic stress time series.
  - Results of the TFN analysis indicate that pumping at Red Hill Shaft has the strongest influence on water level variability in the vicinity of Red Hill, relative to any other stresses evaluated.
  - The TFN analysis allowed both development of step response functions (used to assist with groundwater model calibration) and estimation of aquifer hydraulic properties.
  - All wells respond essentially the same to seasonal trends.

Key CSM Changes in GW Flow Model

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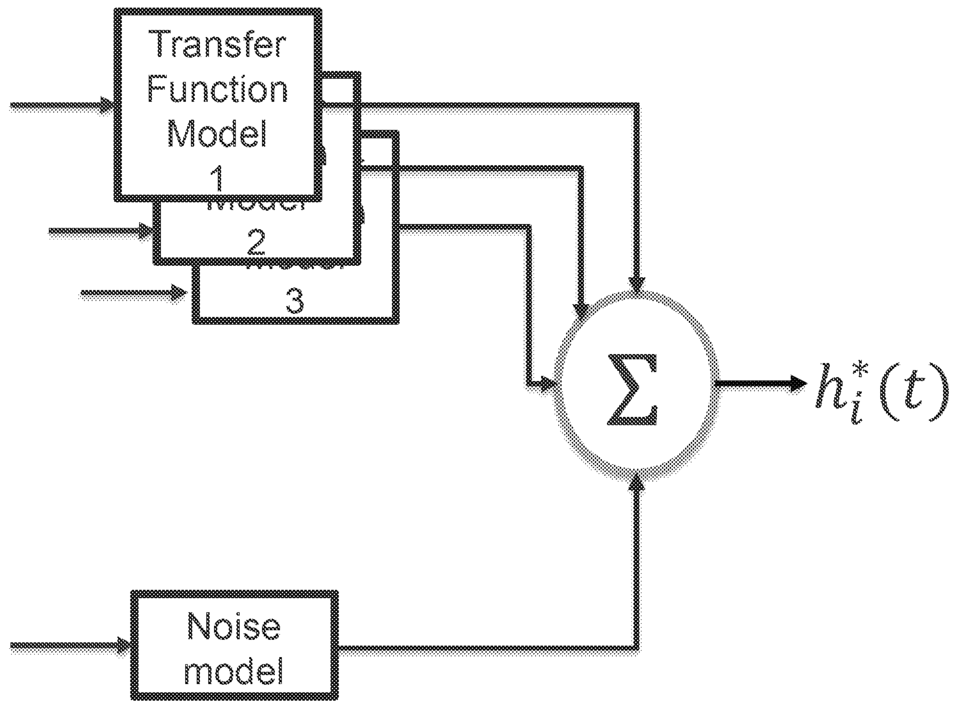
TFN Analysis Objectives

- Quantify contributions of individual hydraulic stresses (e.g., pumping, barometric, and tidal) on water levels at individual wells
- Generate unit response functions to support groundwater model development
- Estimate contributions to water level variations from hydraulic stresses not included in TFN analysis
- Estimate equivalent transmissivity (between pair of pumping shaft and observation well)

Key CSM Changes in GW Flow Model

TFN Analysis - TFN Model with Multiple Input Sources

- Red Hill Shaft
- Hālawa Shaft
- Barometric
- Earth tide

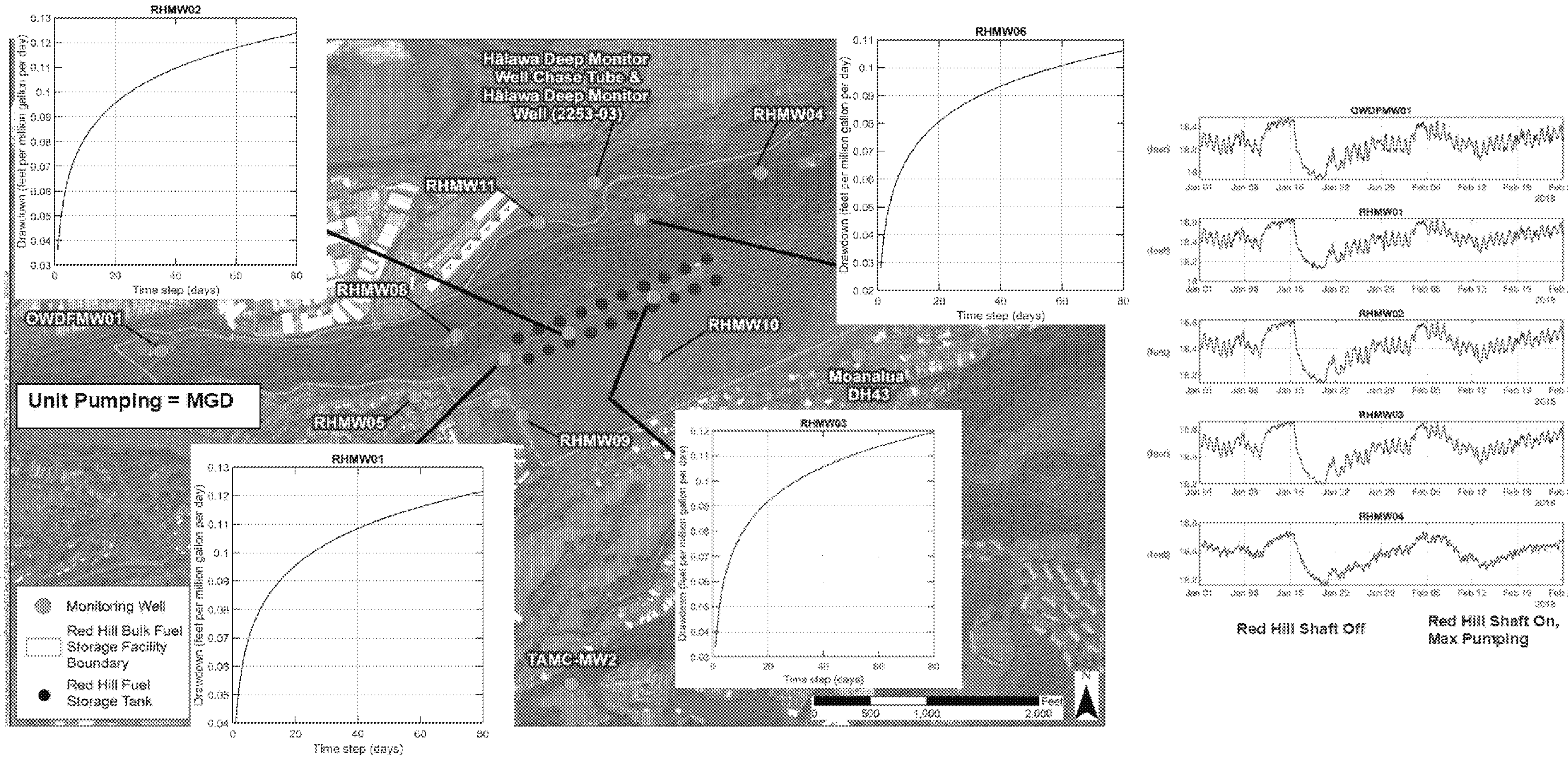


$$\left(y - \mu_y\right) = f(\boldsymbol{k}, x, t) + N_t$$

Convolution / Integration $f(\boldsymbol{k}, x, t) = \sum_{i=1}^{l} v_i(B)(x_{ti} - \mu_{ti})$

Key CSM Changes in GW Flow Model

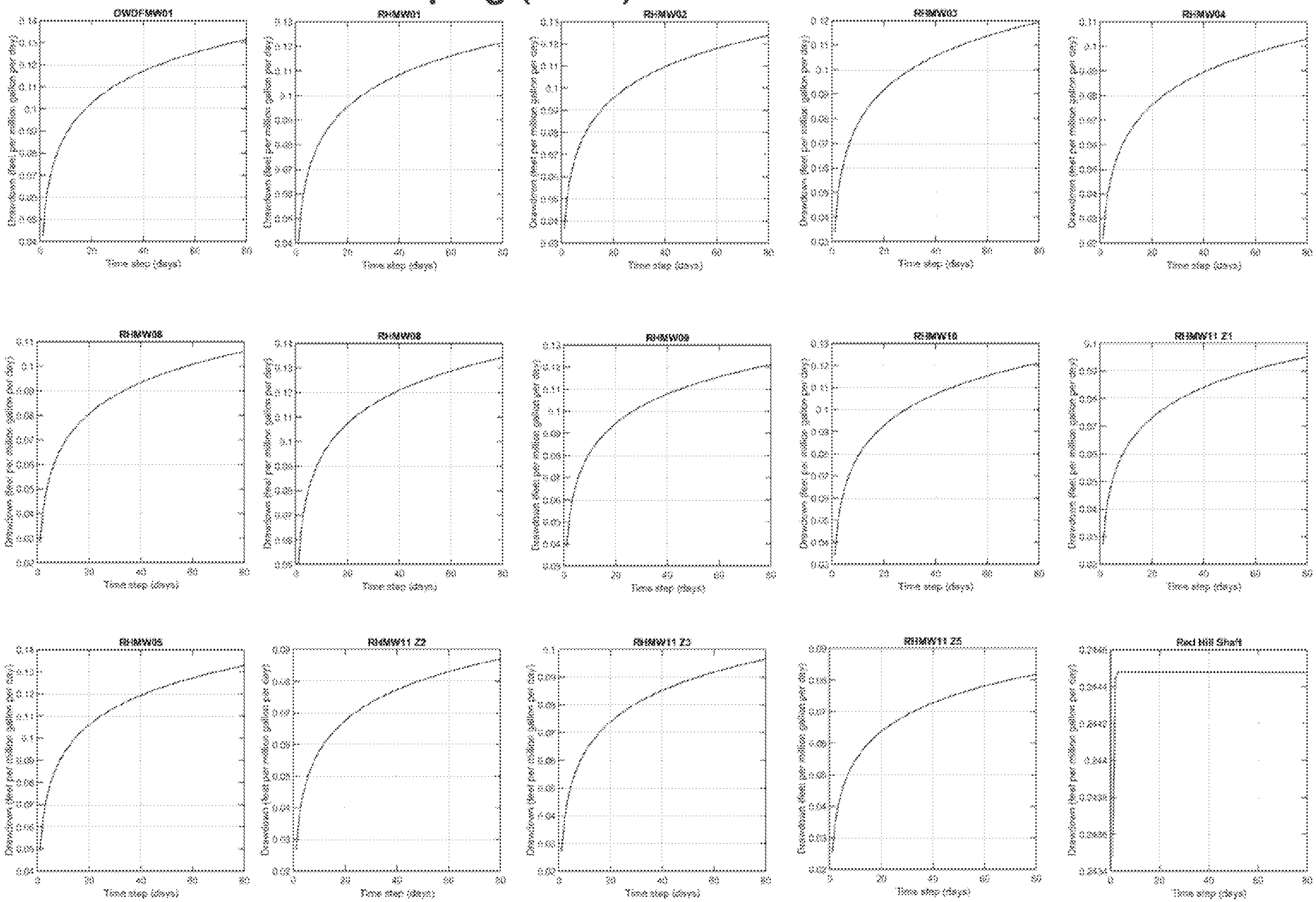
TFN Analysis - Computed Unit Step-Response Functions for Groundwater Model Calibration (Red Hill Shaft Pumping)



Transfer functions are simpler calibration targets than water level observations (without pumping rate variations, barometric effects, and tidal influences)

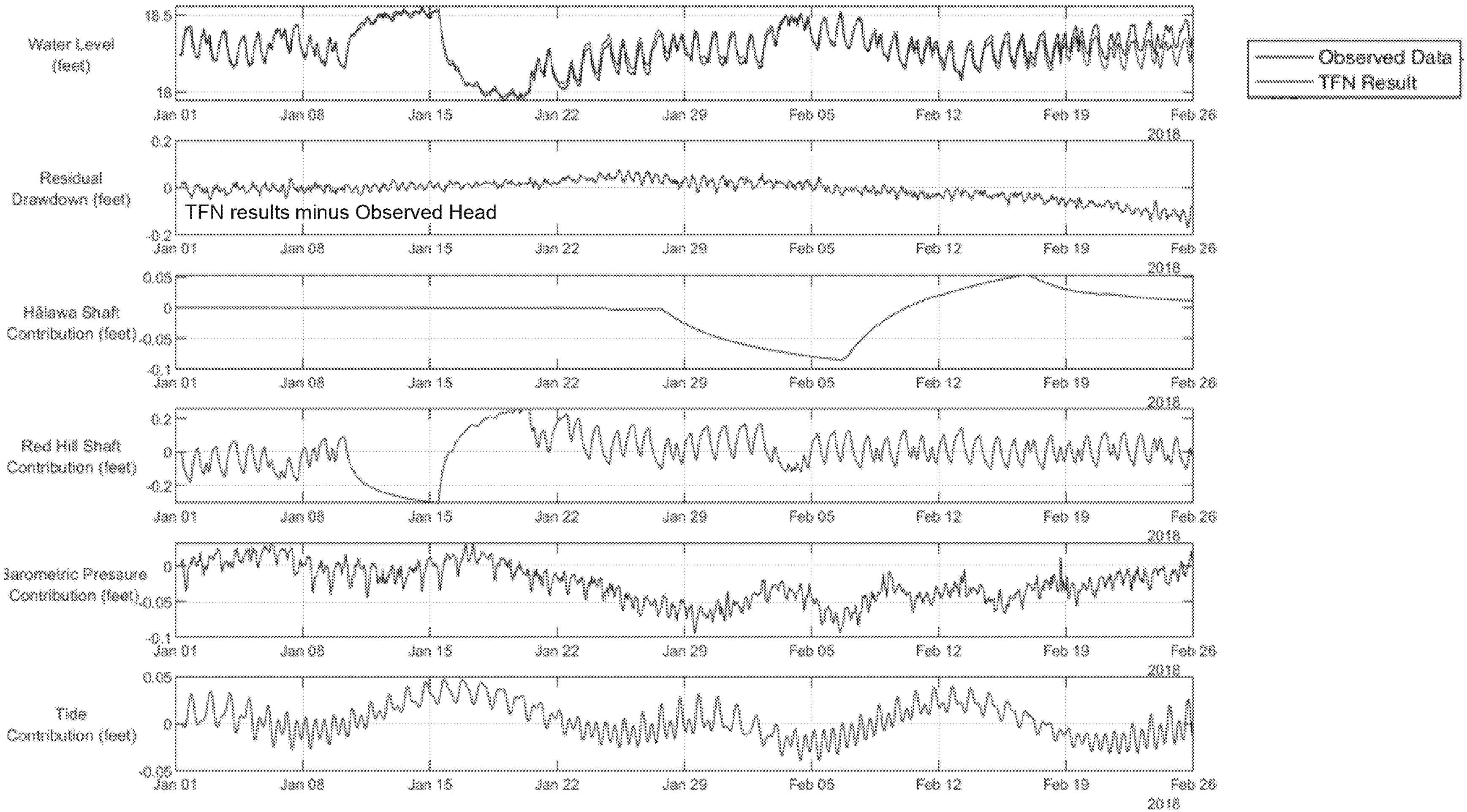
Key CSM Changes in GW Flow Model

TFN Analysis - Computed Unit Step-Response Functions Associated with Red Hill Shaft Pumping (cont.)



Key CSM Changes in GW Flow Model

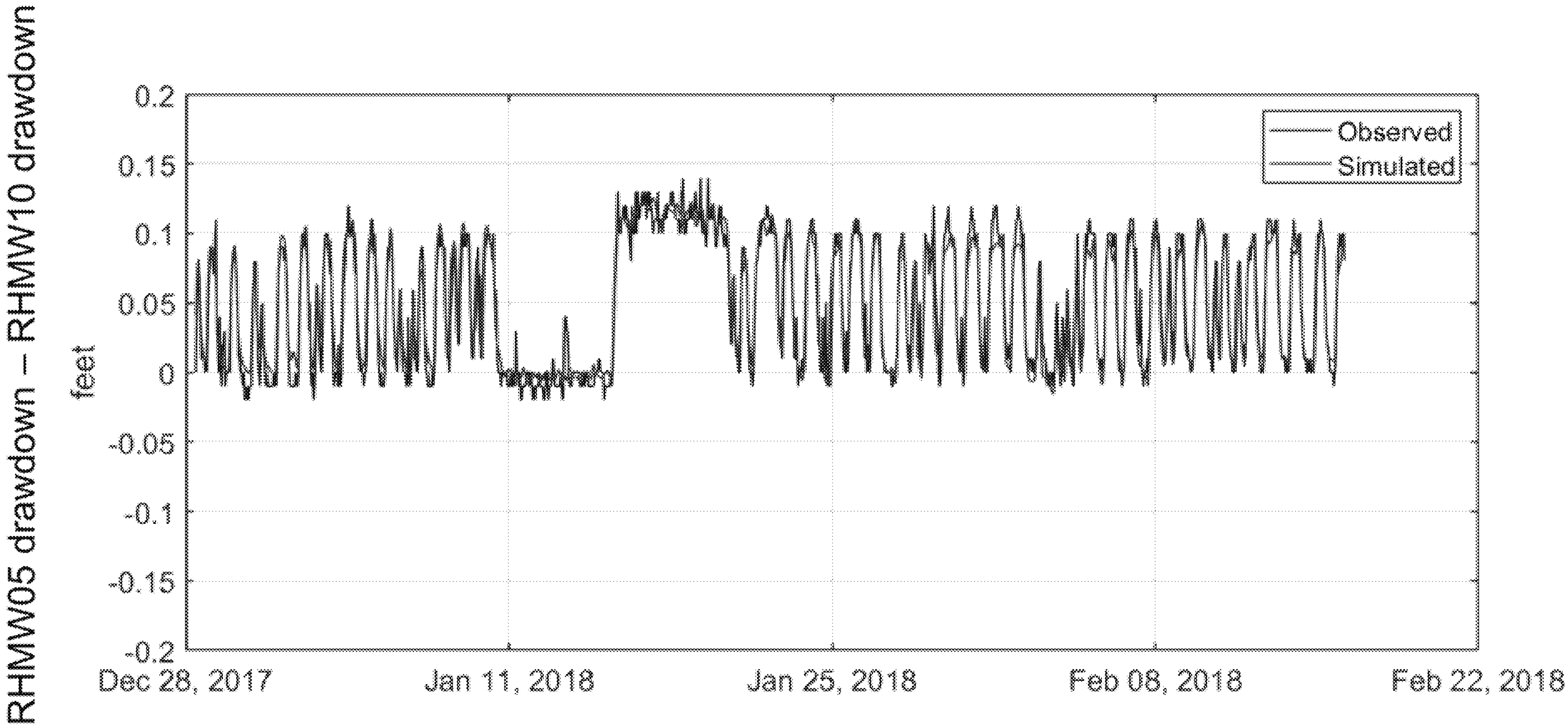
TFN Analysis - Results for RHMW08



Residual fluctuation is small relative to water level fluctuation

Key CSM Changes in GW Flow Model

TFN Analysis - Simulated and Observed Drawdown Difference between RHMW05 and RHMW10



Simulated drawdown/head difference matches observation

Key CSM Changes in GW Flow Model

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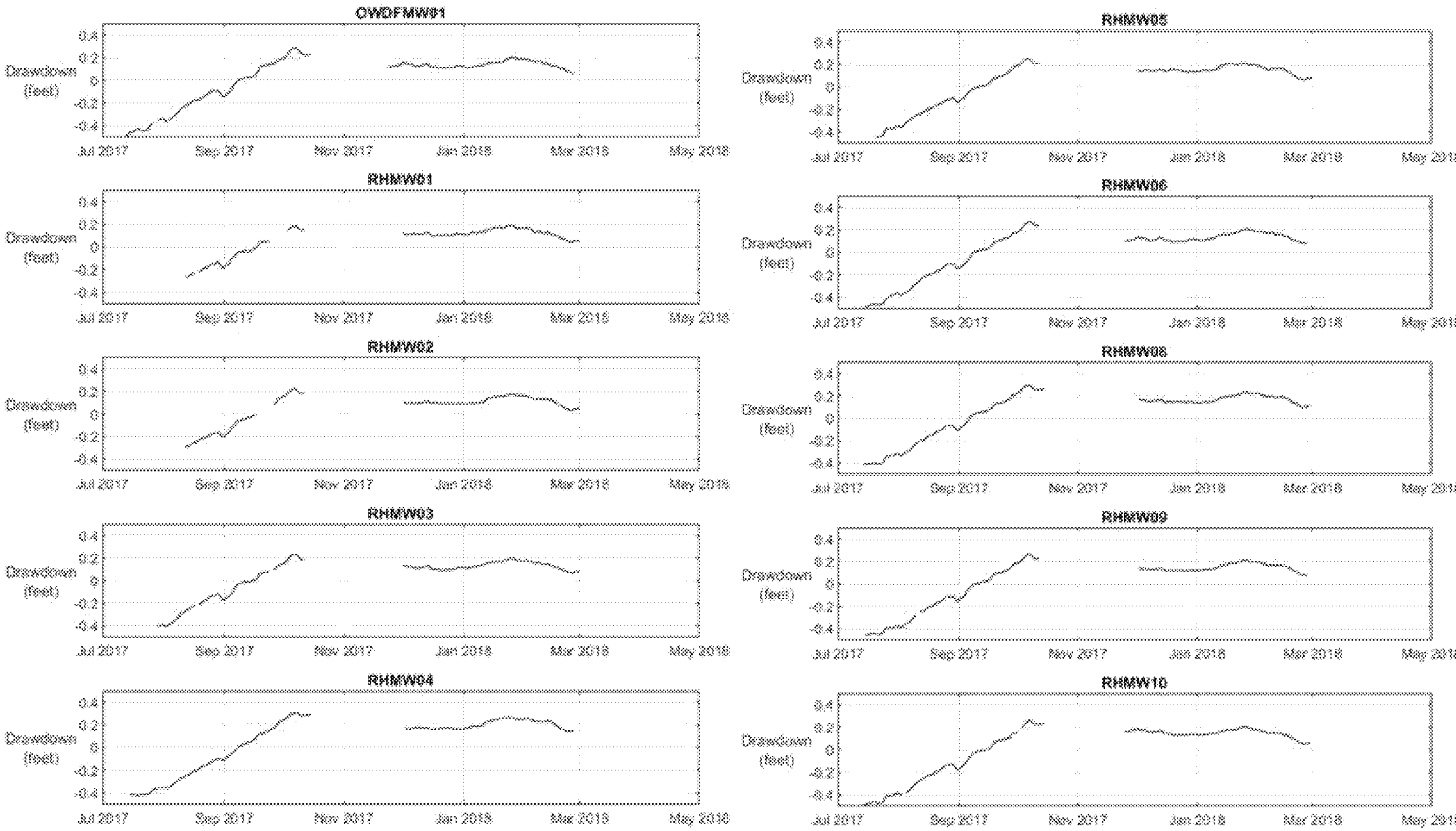
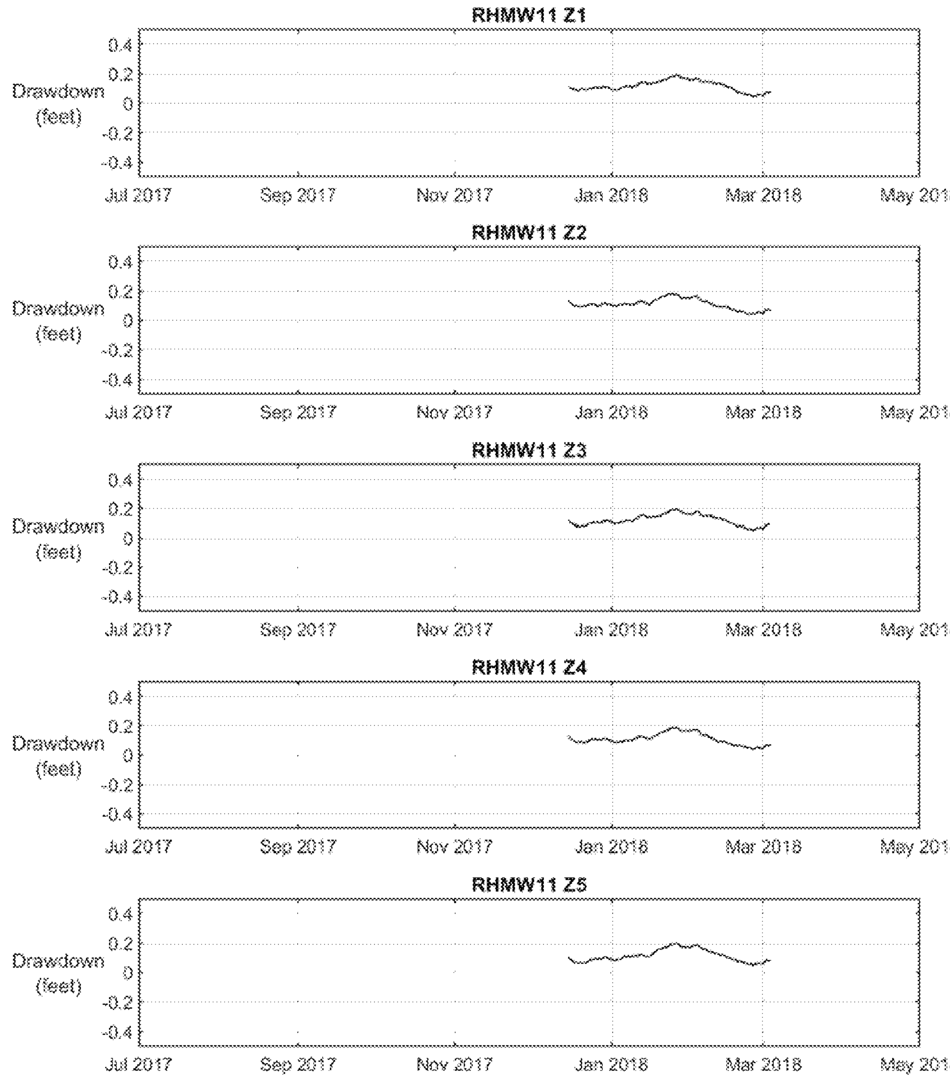
TFN Analysis - Drawdown Residual Time Series from July 2017-March 2018



Consistent long-period influence by 'background' hydraulic stresses (from sources other than pumping, barometric, and tidal influences)

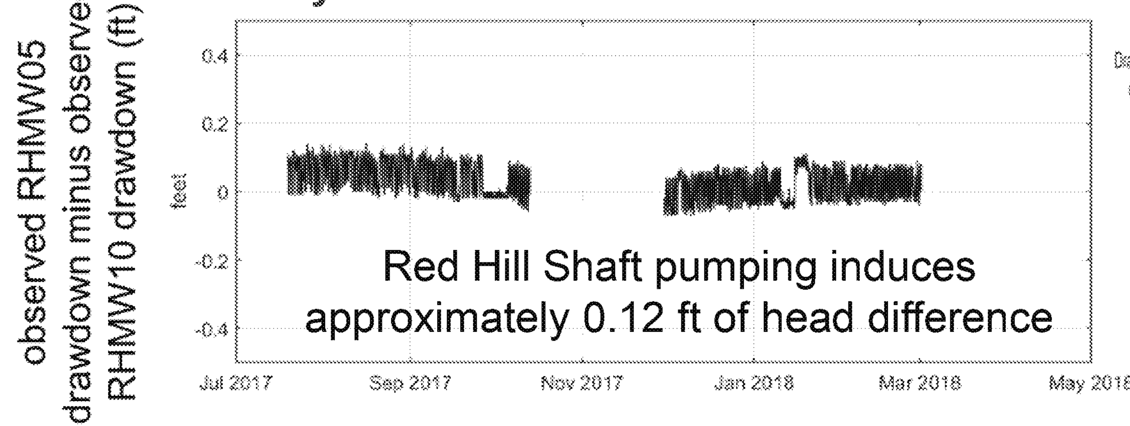
Key CSM Changes in GW Flow Model

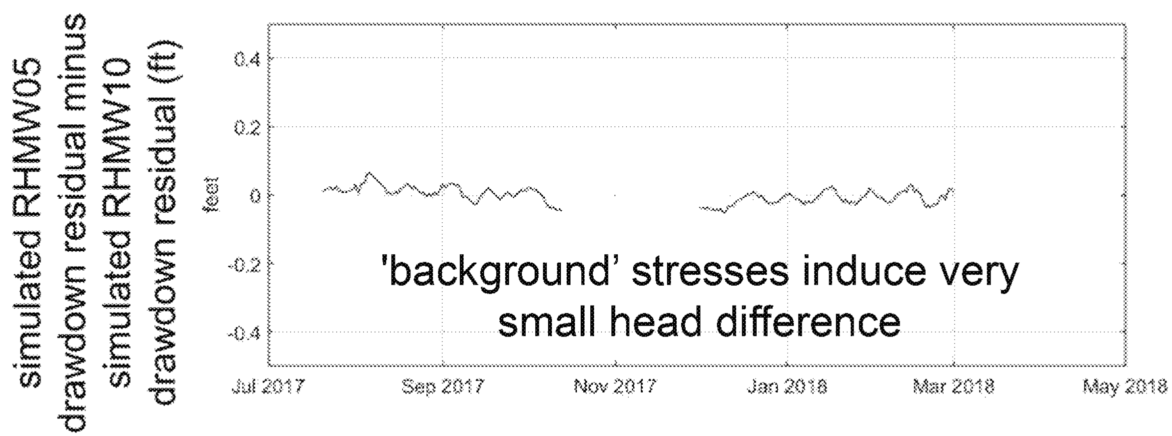
TFN Analysis - Drawdown Residual Time Series from July 2017 –March 2018 (cont.)

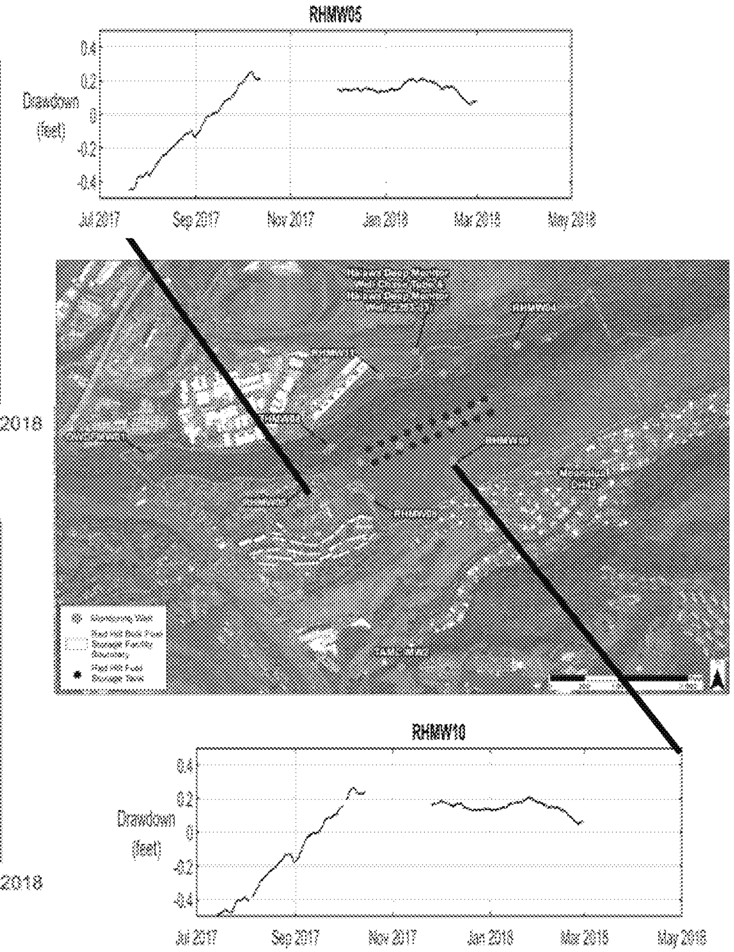


Key CSM Changes in GW Flow Model

TFN Analysis - Head and Residual Differences between RHMW05 and RHMW10 from July 2017– March 2018







Head/drawdown differences caused by 'background' hydraulic stresses is small compared to (1) head variations and (2) pumping contributions

Key CSM Changes in GW Flow Model

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TFN Analysis - Summary

- Red Hill Shaft pumping has a significant effect on monitoring wells at the Facility and is more influential than effects related to pumping at Halawa Shaft (and other pumping wells in the area).
- Precipitation/streamflow did not show an influence on water levels on a daily or weekly basis, indicating that localized recharge is insignificant.
- TFN-based step response function in individual monitoring wells will be used to support model calibration.
- TFN-based hydraulic analyses support very high permeabilities in shallow groundwater beneath Red Hill, which is also demonstrated in the synoptic data review.
- Water level fluctuation due to non-pumping hydraulic sources are spatially consistent, resulting in small hydraulic gradient.
- Red Hill Shaft pumping has a larger impact on hydraulic gradient than other hydraulic stresses.

Working Lunch

Regulatory Agency
Groundwater Flow Model Discussion

Regulatory Agency GW Flow Model Discussion

- DOH to provide slides on measured vs. modeled concerns
- EPA to provide slides on GW flow model fundamentals discussion

Summary of
Key Follow-ups for Day 2 Meeting